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TOO MUCH OF A GOOD THING? UNWANTED SIDE EFFECTS OF SUCCESSFUL INSTRUCTIONAL INTERVENTIONS

Abstract. Starting from results of a laboratory study, the problem of unwanted side effects of instructional interventions is highlighted. The 2x2-factorial experiment examined if learning in the field of empirical research methods could be fostered by feedback and cooperative learning. Students of education and psychology (N = 137) were randomly assigned to one of four experimental conditions: individual learning with and without feedback intervention, and dyadic learning with and without feedback intervention. Students worked with a computer-based learning environment on correlation. The feedback intervention consisted of comprehension tests with elaborated feedback. Results showed that, while cooperative learning did not influence learning outcomes, the feedback intervention had a significant and substantial positive effect on learning. However, for high-ability students, the feedback intervention impaired motivational aspects such as perceived effort and self-efficacy. Implications for instructional practice and further research are discussed.

1. INTRODUCTION

Instructional interventions are generally supposed to maximize learning gains. Also, in order to improve learning in the long run, they often aim at enhancing motivation. Sometimes, however, both goals are not attained at the same time; if the worst comes to the worst, cognitively successful methods can even *impair* motivational aspects (e.g., Stark, Gruber, Renkl, & Mandl, 1998).

These undesirable effects are likely to occur when the intervention does not fit the learner's prerequisites and needs (cf. Stark, Gruber, & Mandl, 1998). This paper outlines a study by Krause, Stark, and Mandl (in press) which indicates the described phenomenon. The study investigated effects of feedback and cooperative learning on computer-based learning in the field of empirical research methods.

2. THE STUDY

2.1. Theoretical background

2.1.1. Computer-based learning in the field of empirical research methods

Students of the social sciences often have difficulties understanding and applying empirical research methods (Broers & Imbos, in press; Krause, Stark, Tyroller, & Mandl, 2003). This problem seems to be due to both unfavorable learning conditions and inadequate prerequisites of the learners. Large numbers of students make individual tutoring difficult. At the same time, deficient cognitive, metacognitive and motivational prerequisites can be diagnosed that often lead to ineffective dealing with the subject matter.

In order to facilitate learning in this field, some instructional interventions have been tested (e.g., Stark & Mandl, 2000). Computer-based learning has gained importance here in recent years (Schulmeister, 2001), as it offers new ways to facilitate self-regulated learning and to adapt instruction to individual needs even under adverse learning conditions (cf. Krause, 2002; Mandl & Krause, 2003).

In this study, a computer-based learning environment on correlation analysis was employed ("Koralle"; Tyroller, Stark, & Mandl, 2002; see also Krause et al., in press) that had previously proved effective (Tyroller et al., 2002). The learning environment is designed according to principles of example-based (cf. Stark, 1999) and problem-oriented learning (cf. Reinmann-Rothmeier & Mandl, 2001). Authentic worked-out examples and problem-solving tasks are systematically combined in order to foster the acquisition of applicable knowledge (cf. Stark, Gruber, Renkl, & Mandl, 2000). To promote learning within Koralle, two instructional interventions were implemented: feedback and cooperative learning. Both interventions were presumed to support reflection and deeper processing of the material.

2.1.2. Instructional interventions: feedback and cooperative learning

By highlighting mistakes and offering explanations or other additional information, feedback enables the learners to reflect on their own understanding and correct their own misconceptions. Several studies confirm the positive impact of feedback both in traditional and computer-based learning environments (see, e.g., Azevedo & Bernard, 1995; Bangert-Drowns, Kulik, Kulik, & Morgan, 1991). Bangert-Drowns et al. (1991) state that, in order to be effective, feedback needs to be processed mindfully by the learner.

Mindfulness (Salomon & Globerson, 1987) can be fostered by cooperative learning; groups are considered to be efficient in confronting misconceptions and ineffective problem-solving strategies (Brown, Collins, & Duguid, 1989). Empirical findings confirm the hypothesis that cooperative learning, at least under certain conditions, fosters student achievement (Cohen, 1994). This is also true for small-group computer learning (Lou, Abrami, & d'Apollonia, 2001). Research on information processing in groups suggests that groups use feedback information more effectively than individuals (cf. Hinsz, Tindale, & Vollrath, 1997). When elaborately discussed, feedback should be received more mindfully in groups. Thus, *group feedback* should be particularly beneficial for learning.

Considering this theoretical and empirical background, both feedback and cooperative learning, especially when combined, seem appropriate to support learning in the field of empirical research methods. Both interventions should enhance learning outcomes. Also, it is very likely that they prolong time on task. However, positive effects should not only be due to longer study times but persist when time on task is statistically controlled.

2.1.3. Role of motivation and metacognition in complex learning

The central role of motivation in complex learning is rarely challenged. Besides, many researchers agree that the acquisition of demanding subject matter requires metacognitive activities such as reflection of one's own comprehension and monitoring of the learning process (cf. Flavell, 1979; Gage & Berliner, 1996; see also Mandl & Krause, 2003; Stark, Gruber, & Mandl, 1998). The presented study is based on the assumption that effective complex learning requires both motivation and metacognition. Facing the complex domain of empirical research methods and the learners' motivational and metacognitive deficits concerning the subject matter, these aspects need special investigation in the context at hand. Therefore, apart from cognitive aspects, motivational and metacognitive prerequisites, process variables and outcome variables were also looked at in this study, e.g. self-efficacy, perceived competence, effort, acceptance of the learning environment and mindfulness in the learning process.

Both feedback and cooperative learning were expected to foster motivational and metacognitive aspects during and after the learning phase. By directly reflecting current understanding (in an informative, non-controlling manner), feedback should promote perceived competence and thus intrinsic motivation (e.g., Deci, Koestner, & Ryan, 2001; Sansone, 1986) and reflection of one's own knowledge and learning process. Cooperative learning should foster intrinsic motivation through perceived relatedness (Deci & Ryan, 1985; see also Johnson & Johnson, 1989) and promote mindfulness through conjoint elaboration and discussion (Salomon & Globerson, 1989).

As both cooperative learning and feedback, especially the latter, can be regarded as scaffolding interventions (Collins, Brown, & Newman, 1989) which might be especially beneficial for learners with less prior knowledge, a differential investigation of cognitive, metacognitive, and motivational effects on *high- and low-ability learners* needs to be part of the analysis.

2.2. Research questions and hypotheses

The study investigated whether learning in the field of empirical research methods can be fostered by feedback and cooperative learning. The following questions were addressed:

(1) To what extent are the experimental groups comparable concerning students' cognitive, metacognitive and motivational prerequisites?

Since the students were randomly assigned to the experimental conditions, groups should be comparable.

(2) To what extent does the computer-based learning environment foster learning progress?

As the first version of the learning environment has proved to foster learning progress, positive effects were expected for the modified version as well. This expectation applies for all experimental groups.

(3) To what extent do the feedback intervention and cooperative learning enhance learning outcomes?

Both instructional interventions were predicted to have positive effects on learning outcomes. Besides, an interaction effect was hypothesized: the feedback intervention was expected to be more beneficial in cooperative than in individual learning.

(4) To what extent do the instructional interventions influence time on task, and is there a correlation between time on task and learning outcomes? Do effects persist when time on task is statistically controlled?

Both interventions were expected to prolong time on task. Moreover, a positive correlation between time on task and learning outcomes was predicted. Because of the hypothesized benefits of the interventions, effects on learning outcomes were expected to remain substantial when time on task is statistically controlled.

(5) To what extent do the instructional interventions influence motivational and metacognitive aspects during and after the learning phase?

Both interventions were presumed to foster motivational and metacognitive process and outcome variables.

2.3. Method

2.3.1. Sample and design

Participants were 137 students, most of whom studied education or psychology. The students took part in the study on a voluntary basis. For participation, prior knowledge of empirical research methods was required. This was assessed beforehand by a short e-mail questionnaire.

In a 2×2-factorial laboratory experiment, the factors "feedback intervention" (available vs. not available) and "social context" (individual vs. cooperative) were varied. Subjects were randomly assigned to the four experimental conditions: individual learning without feedback intervention (n = 17), individual learning with feedback intervention (n = 18), cooperative learning without feedback intervention (n = 25 dyads), and cooperative learning with feedback intervention (n = 26 dyads).

2.3.2. Data sources

Prior knowledge and learning outcomes were assessed by problem-oriented written tests (Tyroller et al., 2002) that were administered before and after the learning phase. Both tests mainly consisted of authentic problem-solving tasks. For the assessment of the learning progress, two tasks were identical in the tests. Data on motivational and metacognitive variables were gathered by means of 6-point rating scales. Time on task was assessed on the basis of logfile data.

2.3.3. Procedure

The students worked either individually or in dyads within the computer-based learning environment. They had to perform authentic problem-solving tasks on correlation analysis. Upon task completion, students received worked-out examples which they could compare with their own solutions. Thus, in all four experimental conditions, some feedback was available. The additional feedback intervention consisted of six problem-oriented comprehension tests with immediate elaborated feedback. The feedback informed students in the two feedback conditions whether or not their answers had been correct and why.

Subjects first completed the pretest and the questionnaire on motivational and metacognitive learning prerequisites. Afterwards, individuals and dyads worked within the learning environment. In the middle of the program, process variables were recorded by means of a short questionnaire. Following the learning phase, the posttest and another questionnaire on motivational and metacognitive aspects were administered. In order to ensure ecological validity of the study, time on task was only minimally restricted: a limit of 200 minutes was not to be exceeded.

2.4. Main results

The four experimental groups were comparable concerning students' cognitive, metacognitive and motivational prerequisites. Results indicated that working within the learning environment led to significant learning progress in all experimental groups ($t(136) = -8.76$, $p < .001$; $d = 1.05$). Table 1 shows that the average posttest scores of all experimental groups were located in the middle of the scale. The overall mean was 12.31 ($SD = 3.02$), which comes up to 61.55% of the theoretical maximum (20 points).

The feedback intervention had a significant and substantial effect on learning outcomes ($F(1,133) = 32.91$, $p < .001$; eta square = .20). Besides, in the feedback conditions, standard deviations were smaller than in the conditions without the feedback intervention, i.e. learning outcomes were more homogenous.

Social context did not significantly influence achievement ($F(1,133) < 1$, *ns*). However, a significant interaction between the two factors "feedback intervention" and "social context" was found ($F(1,133) = 5.03$, $p < .05$; eta square = .04). When students obtained feedback, individuals performed significantly better than dyads, without the feedback intervention, students who worked in dyads were (descriptively) more successful.

Table 1. Pretest and posttest scores and time on task in the four experimental conditions (means and standard deviations)

Experimental condition	*n*	*Pretest score (theoretical maximum: 12)*	*Posttest score (theoretical maximum: 20)*	*Time on task*
Individual learning without feedback	17	4.28 (2.13)	10.25 (3.41)	70.06 (24.05)
Individual learning with feedback	18	4.24 (2.33)	14.51 (2.15)	104.11 (23.72)
Cooperative learning without feedback	25 dyads	4.71 (1.90)	11.31 (3.06)	85.80 (29.77)
Cooperative learning with feedback	26 dyads	5.07 (1.54)	13.18 (2.28)	117.85 (21.27)

Both interventions prolonged time on task (see table 1), and time on task was significantly correlated with learning outcomes ($r = .28$, $p < .01$). Therefore, time on task was accounted for as a covariate. The main effect of the feedback intervention and the interaction effect remained significant and substantial when time on task was statistically controlled (effect of feedback: $F(1,132) = 19.92$, $p < .001$; eta square = .13; interaction effect: $F(1,132) = 4.95$, $p < .05$; eta square = .04).

As far as motivational and metacognitive prerequisites were concerned, most overall means were rather high (e.g., learning goal orientation: $M = 5.27$, $SD = .51$; metacognitive knowledge: $M = 4.46$, $SD = .41$; theoretical maximum: 6). The expected beneficial effects of feedback and cooperative learning on motivation and metacognition were not found. On the contrary, the feedback intervention had *negative* effects for *high-ability students*, i.e. students who attained over 4.75 points (out of 12) in the pretest (see table 2).

Table 2. High-ability learners' motivation and metacognition during and after the learning phase: aspects that were impaired by the feedback intervention (means and standard deviations; theoretical maximum: 6)

Experimental condition	*Perceived self-efficacy*	*Perceived effort*	*Perceived competence*	*Perceived mindfulness*	*Acceptance of learning environment*
Individual learning without feedback	4.76 (.71)	5.43 (.45)	5.00 (.77)	5.38 (.30)	4.97 (.35)
Individual learning with feedback	4.00 (.91)	4.38 (1.22)	4.00 (.80)	4.75 (.43)	4.55 (.63)
Cooperative learning without feedback	4.70 (.78)	4.71 (.80)	4.67 (.75)	5.13 (.64)	4.87 (.55)
Cooperative learning with feedback	4.51 (.79)	4.90 (.69)	4.31 (.79)	5.13 (.59)	4.62 (.61)

In this sub-group (n = 65), the intervention diminished perceived self-efficacy (F(1,61) = 4.10, p < .05; eta square = .06), effort (F(1,61) = 3.52, p < .10; eta square = .06), and perceived competence (F(1,61) = 8.75, p < .01; eta square = .13). High-ability learners also showed less acceptance of the learning environment when feedback was provided (F(1,61) = 3.78, p < .10; eta square = .06). Moreover, one metacognitive aspect was impaired: in the feedback conditions, high-ability learners reported less mindfulness in the learning process (F(1,61) = 3.55, p < .10; eta square = .06).

However, this only holds for *individual* learning. In *cooperative* learning, feedback did not significantly diminish these aspects. For perceived effort and mindfulness, the interaction effect of the two factors "feedback intervention" and "social context" was (almost) significant (effort: F(1,61) = 3.54, p < .10; eta square = .06; mindfulness: F (1,61) = 7.09, p < .05; eta square = .10).

2.5. Discussion

As expected, the learning environment fostered learning progress. It therefore can be employed to facilitate learning in the field of empirical research methods. This is also true for the feedback intervention, as it substantially promoted knowledge acquisition (independent of time on task) and at the same time resulted in more homogenous learning outcomes. Cooperative learning, however, did not foster learning. Perhaps, due to the well-structured domain, there was not enough room for discussion. Another possible explanation lies in the nature of the task. In order to ensure internal validity, the task was designed in a way that both individuals and groups could successfully deal with it. This means that it was not a "true" group task which requires the sharing of resources, such as knowledge or problem-solving strategies, and thus induces interdependence of group members (Cohen, 1994).

Concerning the predicted interaction effect, the *opposite* pattern was found: when additional feedback was provided, students who worked *individually* outperformed those who worked in dyads. Apparently, individuals used the feedback more effectively than dyads. Thus, the hypothesis that feedback is especially effective in cooperative learning was not confirmed. It is conceivable that in the *group-feedback* condition, there was an "excess supply" of instructional interventions that led to distraction rather than higher mindfulness in the learning process. In the group-feedback condition, mindfulness might have been inhibited by additional incidental processing (Mayer & Moreno, 2003) that led to floundering (Anderson, Corbett, Koedinger, & Pelletier, 1995) or cognitive overload (Sweller, 1999). Given the research deficit concerning *group feedback in learning settings* (cf. Krause, Stark, & Mandl, 2003), however, more research is needed here.

Other than expected, both interventions did not foster motivation and metacognition. This might be due to the fact that, as participation was voluntary, learning prerequisites were comparably advantageous. When students are *obliged* to take part, e.g. in the context of a regular statistics course, the instructional interventions might compensate for deficits in motivation or metacognition.

In this context, however, a *converse* effect was found. When high-ability learners worked individually, the feedback intervention even *impaired* motivational and metacognitive aspects. One possible explanation for these results is that the extensive instructional guidance in the feedback conditions made learning "too easy" for high-ability students. Thus, they felt that learning did not require much effort and mindfulness. This also made them perceive less self-efficacy and competence in the learning process. To sum up, the depicted problem might be due to a lack of *challenge* (cf. Lepper & Malone, 1987). Another explanation might be that students felt "spoon-fed" and controlled by the feedback intervention. If this was the case, detrimental effects were caused by a lack of *autonomy* (Deci & Ryan, 1985). Nonetheless, the feedback intervention had a significant and substantial *positive* impact on *cognitive* outcomes for both high-ability and low-ability learners.

Interestingly, the negative effect of the feedback intervention on motivation and metacognition only held true for *individual* learning. The interaction effects of the two factors on perceived effort and mindfulness indicate that *cooperative* learning to some extent compensated for the detrimental effect of the feedback intervention. This might be explained by the fact that interaction with a learning partner requires additional effort and mindfulness and allows feelings of self-efficacy, competence and relatedness (Deci & Ryan, 1985). So, concerning motivation and metacognition of high-ability learners, the group-feedback condition was superior to the individual-feedback condition. Further research on group feedback in learning settings should pay special attention to this aspect.

3. CONCLUSION

Kalyuga, Ayres, Chandler, and Sweller (2003) point out that instructional interventions can have negative *cognitive* consequences for high-ability learners. They call this phenomenon the *expertise reversal effect*. Apparently, there is an analogous phenomenon concerning motivational and metacognitive aspects: the presented results show that successful instructional interventions can undermine motivation and (perceived) metacognitive activities. They also show that these unwanted side effects can depend on levels of student expertise. Instructional practice has to account for this risk.

The presented results suggest that for high-ability learners, guidance and control should be minimized – i.e., it is necessary to avoid "instructional overkill". Motivational and metacognitive benefits for high-ability learners might be expected from high degrees of challenge and autonomy in the learning process. Besides, in light of the presented findings, it seems possible to compensate for detrimental effects of instruction on high-ability learners' motivation and metacognition by cooperative learning.

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